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TECHNICAL REPORT

Fish Kill Associated with the January 5, 1980 Outage at Oyster Creek
Nuclear Generating Station

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Jersey Central Power & Light Co.

March 1980

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5/5/10 OCLC # 605 865 199 Horizon # 402 675

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1) Introduction

The Oyster Creek Nuclear Generating Station (OCNGS) began operation in late 1969. In early 1972 a large number of Atlantic menhaden died after a winter shutdown. Similar kills occurred in subsequent years. In 1975 changes were made in operation and shutdown procedures, which were intended to minimize the impact of winter shutdowns on fish. Winter shutdowns between 1975 and 1979 had relatively small kills of Atlantic menhaden associated with them. On January 5, 1980 OCNGS shut down. OCNGS stopped generating electricity at 0225 hours. Subsequent to the shutdown, approximately 7000 fish died.

This report summarizes the results of fish sampled and collected prior to and after the shutdown and provides an assessment of the impact of the loss of these organisms. The report also compares the size of the fish kill with prior kills associated with other winter outages at OCNGS and provides an assessment of the effectiveness of various changes which have been instituted in the operation and shutdown procedures at OCNGS intended to minimize the impact of the shutdowns on fish. This report supercedes a preliminary report produced shortly after the shutdown.

2) Environmental and Plant Operating Conditions Before and After Shutdown

OCNGS monitors meteorological and water temperature conditions continuously. During the ten days prior to the January 5, 1980 outage (see Table 1), the average OCNGS intake water temperature was approximately 39.1 F (3.94 C). The average intake water temperature on January 5, 1980 was 33.9 F (1.06 C). The difference is due in part to the normal decline of ambient water temperature associated with the onset of winter and more particularly with the passage of a cold front through Ocean County, New Jersey during the night of January 4 and the morning of January 5, 1980. The cold front was observed to pass through the vicinity of OCNGS at approximately 1900 to 2000 hours on January 4, 1980 and was characterized by winds of between 10-14 mph from the northeast. Heavy snowfall and poor visibility accompanied the cold front.

The shutdown began on January 4, 1980 at 2200 hours (see Table 2). At approximately 2300 hours the reactor reached 70% power level and both dilution pumps were shut off. On January 4, 1980 at 2342 hours one circulating water pump was shut down. At 0225 hours on January 5, 1980, OCNGS came off the line. The remaining three circulating pumps continued to circulate water, rejecting residual waste heat into the discharge canal.

As a result of the changes in power level and pumping the discharge temperature went from 54.2 F (12.33 C) to 35.8 F (2.11 C) over a period of 7.5 hours producing a rate of temperature decline of approximately 2.5 F per hour (See Figure 1). During

the same period, the U.S. Rt. 9 bridge temperature went from 44.7 F (7.06 C) to 50.6 F (10.33 C) after the dilution pumps were turned off and subsequently down to 37.1 F (1.83 C). Intake water temperature declined from 35.6 F (2.00 C) to 33.9 F (1.06 C).

Between January 6 and January 10, 1980 intake water temperatures varied between 32.8 and 33.8 F with an average of 33.32 F (0.73 C). On January 5, 1980 and on subsequent days, ice was found in discontinuous sheets along the main stem of Oyster Creek and in solid sheets in the residential lagoons on the south side of Oyster Creek near its confluence with Barnegat Bay.

3) Methods

A pre-shutdown survey of fish in the discharge canal was conducted on January 2 and January 3, 1980 (See Attachment I). A 4.8 meter semi-balloon trawl which has a 3.9 cm stretch mesh body and a 3.2 cm stretch mesh cod end with a 1.3 cm stretch mesh liner, was used to collect two five minute trawls at the mouth of Oyster Creek and just east of U.S. Rt. 9 bridge and one trawl the length of the eastern lagoon. A 60 meter by 2.4 meter monofilament gill net which had two 30 meter panels, one of 3.9 cm stretch mesh and the other of 8.5 cm stretch mesh, was used for two half hour periods at the mouth of Oyster Creek and for five minutes next to the condenser discharge of OCNCS. Subsequent to the shutdown, the same two gear types were used at the same stations with the exception that the gill net was not deployed at the mouth of Oyster Creek due to ice sheets. All fish captured during these surveys were identified to the lowest possible taxa and enumerated completely or estimated. Lengths were measured for key species. Other pre-shutdown work was conducted and is reported elsewhere (Ecological Analysts, in prep.).

The object of the post-shutdown collection was to remove as many of the dead specimens as possible so as to minimize double counting. Immediately after the OCNCS shutdown, stressed and or dying fish were counted and collected from the shoreline along the discharge canal by dip netting. Specimens were collected in the immediate vicinity of the condenser discharge after the plant came off line and were collected along the length of the discharge canal down to and including the wide area of Oyster Creek adjacent to the former marina sites. The dip netted fish were counted either as they were collected or after being combined. Portions of the entire length of the discharge canal were observed on January 5, and 7. Observations were made at U.S. Rt. 9 on January 8th, 1980. Ice conditions on the banks precluded shore collection of specimens in some portions of the discharge canal.

4) Observations

During the pre-shutdown survey it became obvious the discharge

canal contained a very large number of Atlantic menhaden (Brevoortia tyrannus) in the immediate vicinity of the condenser discharge. The fish were observed swimming into the condenser discharge tunnel and were packed tightly both horizontally and vertically. The areal extent of the Atlantic menhaden, as delineated by their breaking the water surface, was a triangular shaped area adjacent to the eastern-most port of the condenser discharge. Based on an extrapolation of several transect counts across the eastern port, it was estimated that this port contained three to five thousand Atlantic menhaden. After sampling other portions of Oyster Creek and the discharge canal, it appeared Atlantic menhaden were confined almost exclusively to this area although one fisherman reported catching one bluefish (Pomatomus saltatrix) and one Atlantic menhaden on the Monday (12/31/80) prior to the shutdown. No bluefish, weakfish (Cynoscion regalis), or spot (Leiostomus xanthurus) were collected during the pre-shutdown survey.

Immediately prior to the shutdown, Atlantic menhaden continued to be found almost exclusively in the eastern-most condenser port, swimming strongly into the discharge flow. As the shutdown progressed and dilution pumps were removed from service, this behavior continued. Almost immediately after the plant came off line, bluefish and weakfish were observed at the surface moving passively just west of the eastern discharge port at a discharge temperature of approximately 42 to 43 F (5.6 to 6.1 C). Atlantic menhaden began to exhibit signs of stress (approximately 0300 hours), when the discharge temperature was between 41 and 42 F (5.0 to 5.6 C).

Between 0300 hours and 0400 hours bluefish were first dip netted in the vicinity of U.S. Rt. 9 bridge. After 0400 hours, weakfish also began to appear in the vicinity of the bridge. Subsequent to 0430 hours Atlantic menhaden appeared at the U.S. Rt. 9 bridge and they continued to move into the shore area until approximately 1100 hours. After 1100 hours, the rate of appearance of new specimens in the shore areas stopped. During this time period, approximately 3000 specimens were collected by dip netting along the shoreline. The shoreline in the vicinity of the U.S. Rt. 9 bridge contained many more specimens than the other areas of shoreline possibly due to the influx of warmer, fresh water from Oyster Creek ponding over the surface. Visual observations made from the U.S. Rt. 9 bridge and from a boat revealed the largest concentrations of beached fish were mainly in the vicinity of the Rt. 9 bridge.

5) Data Analysis

Estimates of the number of fish killed were produced by linear extrapolation from the number of collected organisms and assuming 75% of the dead specimens would be found near the shore (American Fisheries Society, 1979). Specimens collected between 1/5 and 1/7/80 by JCP&L and Ecological Analysts (EA) are as follows:

<u>Area</u>	<u>Menhaden</u>	<u>Bluefish</u>	<u>Weakfish</u>	<u>Spot</u>	<u>Scup</u>	<u>Kingfish</u>
O.C. Shoreline	2778	642	29	5	2	1
O.C. Bottom	3	1	-	-	-	-
Lagoon Bottoms	2	-	-	-	-	-

Estimates for the OC Shoreline were extrapolated by the 75% factor (Estimate = Actual/75%) to include the bottom and the shoreline (See Attachment II for equations); estimates for the OC Bottom were produced by computing a specimen per area figure for the area sampled and extrapolating that figure to cover the total bottom and then extrapolating that number to a total for bottom and shoreline by the 75% factor (Estimate = [(Actual number/area sampled) x total area]/25%); estimates for the Lagoon Bottoms were produced by computing a specimen per area figure for the area sampled and extrapolating that figure to cover the total bottom of the four lagoons. Computation of the OC Shoreline and OC Bottom estimates should produce an overestimate since some areas were sampled both from the shore and the water. The estimates are as follows:

<u>Area</u>	<u>Menhaden</u>	<u>Bluefish</u>	<u>Weakfish</u>	<u>Spot</u>	<u>Scup</u>	<u>Kingfish</u>
O.C. Shoreline	3704	856	39	7	3	1
O.C. Bottom	283	94	-	-	-	-
Lagoon Bottoms	50	-	-	-	-	-
Total	4037	950	39	7	3	1

Dead specimens were counted on 1/8/80 from shoreline and trawl by JCP&L, EA and the USNRC as follows:

<u>Area</u>	<u>Menhaden</u>	<u>Bluefish</u>	<u>Weakfish</u>	<u>Spot</u>	<u>Scup</u>	<u>Butterfish</u>
O.C. Shoreline	328	1	3	51	1	1
Bay Shoreline	5	1	-	-	-	1
O.C. Bottom	4	-	-	-	-	-
O.C. Lagoons	20	-	-	-	-	-

Extrapolating the counted specimens as above produces the following estimates:

<u>Area</u>	<u>Menhaden</u>	<u>Bluefish</u>	<u>Weakfish</u>	<u>Spot</u>	<u>Scup</u>	<u>Butterfish</u>
O.C. Shoreline	437	1	4	68	1	1
Bay Shoreline	7	1	-	-	1	-
O.C. Bottom	667	-	-	-	-	-
O.C. Lagoons	260	-	-	-	-	-
Total	1371	2	4	68	2	1

Live specimens of Atlantic menhaden and spot were found in Oyster Creek and the lagoons in the trawls. Assuming these live

specimens died after the sampling, the following totals would be produced:

	<u>Menhaden</u>	<u>Spot</u>
Number	75	469

Adding the three totals provides a final total number for the kill as follows:

	<u>Menhaden</u>	<u>Bluefish</u>	<u>Weakfish</u>	<u>Spot</u>	<u>Scup</u>	<u>Butterfish</u>	<u>Kingfish</u>
Number	5483	952	43	544	5	1	1

Weights were measured for the Atlantic menhaden, bluefish and weakfish allowing a total weight estimate to be computed as shown below:

	<u>Menhaden</u>	<u>Bluefish</u>	<u>Weakfish</u>
weight (kg)	1590	371	60

Weights for Spot, Scup, Kingfish and Butterfish were estimated from the known length and length-weight relationships (Hildebrand and Schroeder, 1928) to produce a weight per species estimate as follows:

	<u>Spot</u>	<u>Scup</u>	<u>Kingfish</u>	<u>Butterfish</u>
Weight (kg)	.71	.85	.12	.04

The above number and weight estimates are derived from computations, assumptions and field observations. Estimation of error is discussed in a subsequent section.

6) Discussion

6.1 Causal mechanism for kill

Based on the temperature and species data associated with prior fish kills at OCNCS (JCP&L, 1978) and the cold shock literature for the affected species, the fish died because the ambient water temperature was below their respective lower lethal temperatures (Table 3). After the shutdown, ambient water temperature was 33.9 F (1.06 C). Lower lethal temperatures for the affected species are: Atlantic menhaden - 37 F (3 C); bluefish - between 40 and 47 F (3.3 and 8.5 C); weakfish - below (10 C) 50 F; spot - 37 F (3 C). No data has been found for the other species.

Based on 1) collection of live Atlantic menhaden and spot on 1/7/80 in the lagoons; 2) the observation of dead menhaden and spot on 1/8/80 in the areas where no dead specimens were observed on 1/7/80; and 3) past fish kill experience (JCP&L, 1978), it is

likely that Atlantic menhaden and spot moved into the lagoons after the OCNGS shutdown, and died between 1/7 and 1/8/80 as the lagoon water temperatures declined. It is reasonable to assume that less mortality would have occurred if ambient temperatures were higher.

6.2 Estimation of kill

Accurate estimates of the number of fish which died after a fish kill are difficult to make. The post-shutdown monitoring effort was devoted to collecting all dead specimens along accessible shores and estimating the number of dead specimens on the bottom by bottom trawling. The estimates could be low due to the following factors: 1) fish die outside of sampled area and are not counted; 2) dead fish are washed out of the sampled area and are not counted; 3) fish die in sampled area but are not counted. These factors are discussed below:

Factor 1 - Due to the low water temperatures, it is probable that most of the Atlantic menhaden and all of the bluefish and weakfish died quickly after OCNGS went off line. Prior to the shutdown, the U.S. Rt. 9 bridge temperature was below the lower lethal temperature for bluefish and weakfish. Some Atlantic menhaden and spot did actively move down the discharge canal and into the lagoons near the mouth of Oyster Creek - an area which cools down much slower than the main portion of Oyster Creek. Since the Bay temperature (33.9 F; 1.06 C) was lower than the Atlantic menhaden and spot's lower lethal temperatures it is unlikely that these species would actively move into the Bay. Because of these considerations it is improbable that Factor 1 would have significantly affected the estimates of the kill.

Factor 2 - The discharge canal has significant and competent flows when OCNGS is operating dilution and/or circulating water pumps. Measurements in the discharge canal have shown velocities of 1.0 to 1.5 feet per second (fps) in the narrow portions and 0.5 to .7 fps in the wider portions when OCNGS is pumping 720,000 gallon per minute (gpm) (Woodward - Envicon, Inc., 1973). After the shutdown, OCNGS pumped 345,000 gpm which should have resulted in velocities of 0.5 to 0.7 fps in the narrow portions and 0.2 to 0.3 to the wider portions of the canal. Post-shutdown trawling in Oyster Creek and in Barnegat Bay near the mouth of Oyster Creek picked up dead Atlantic menhaden (6) and bluefish (1). All specimens were collected in the higher velocity areas thereby indicating the velocities were not sufficient to wash the organisms into the bay.

These collections would not allow the conclusion that specimens were not washed into Barnegat Bay but observations of the shoreline of the Bay after the shutdown revealed few specimens - none to the north of Oyster Creek and 7 menhaden, 1 bluefish and 1 scup south of Oyster Creek (Masnik, 1980; Danila, 1980). Wind conditions on January 5 and 6, 1980 would have blown dead fish to

the south in the Bay yet observations made of the Bay's shore south of Oyster Creek between January 5 and January 8, 1980 revealed little or no gull activity so common after fish kills.

Based on the paucity of dead fish found along the shore in the Bay and the presence of dead Atlantic menhaden on the bottom of Oyster Creek it is unlikely that Factor 2 has significantly affected the fish kill estimates.

Factor 3 - Oyster Creek, from OCNGS to Barnegat Bay, contains much bottom and shoreline which was not directly sampled. A significant effort was made to sample and collect dead specimens from representative areas in the discharge canal. The geographic distribution of the collected specimens indicated dead fish preferentially accumulated in the same areas as in the past kills, i.e. the discharge canal near the Rt. 9 bridge and the lagoons. Other areas were checked but yielded relatively few specimens. The reason for the preferential accumulation is considered to be related to the Atlantic menhaden seeking higher temperature water found in these two areas.

Based upon the results of the collection effort, the data from past fish kills, and the general behavior of fish it is unlikely that a large number of dead fish were missed in the sampling area, either along the shoreline or on the bottom. Since the bottom estimates were extrapolated to cover a shoreline component, the fish taken by gulls and residents should be included in the estimates.

No attempts were made to compute a standard error during the field measurements. Since the accuracy of estimate increases with the number counted, the Atlantic menhaden estimates are most accurate and the other species estimates least accurate. Standard errors of 10% and 50% would not be unreasonable for the Atlantic menhaden and other species respectively.

6.3 Comparison With Prior Kills

Eleven cold shock fish kills have occurred at OCNGS prior to this kill (Table 4). Prior to 1975, four cold shock kills occurred with estimated losses ranging from a thousand to a million Atlantic menhaden and a hundred to a thousand bluefish. Subsequent to 1975, operating changes were made at OCNGS to minimize cold shock from fish kills: two dilution pumps are operated during Fall and Winter and dilution pumps are shut off immediately after an automatic shutdown. The first change is intended to reduce the number of fish attracted to the discharge canal and the second is to lengthen the cooldown time of the discharge canal to allow the fish in the canal to acclimate to the lower temperatures. Since these changes were instituted, six cold shock fish kills have occurred with Atlantic menhaden losses of a hundred to a thousand - a significant decrease from prior to the institution of the changes. The loss associated with the 1/5/80 shutdown is the largest since the institution of the

changes but is smaller than most of the pre-1975 cold shock kills. Because of this it is concluded the changes have helped reduce the mortality although it is clear the changes have not eliminated it.

6.4 Assessment of Loss

Loss of organisms from a population can be evaluated in many different ways. Atlantic menhaden, bluefish, weakfish and spot are collected commercially in New Jersey and loss of these specimens will produce an immediate loss to these fisheries. 1978 landing data (National Marine Fisheries Service, 1979) shows 37,388,725 kg. of Atlantic menhaden, 719,012 kg. of bluefish, 1,602,388 kg. of weakfish and 4,976 kg. of spot were commercially landed in New Jersey. The estimated 1980 fish kill loss is an extremely small fraction of these landings: .004% for Atlantic menhaden, .05% for bluefish, .004% for weakfish, and 1.4% for spot.

Commercial landings from New Jersey enables a computation of economic value for these four species in 1978 dollars:

	<u>Menhaden</u>	<u>Bluefish</u>	<u>Weakfish</u>	<u>Spot</u>
\$/kg.	.07	.33	.40	.58
Total \$	111.30	122.43	24.00	41.06

The other species will have a negligible commercial value and therefore, the lost commercial value of the entire kill will be about \$345 in 1980 dollars assuming a 7% per year increase due to inflation.

6.5 Future Mitigation Efforts

Fish are attracted to the OCNCS discharge canal during the Fall. As the water temperatures in the Bay decline, the fish appear to move into the condenser discharge area achieving extremely high fish densities in the eastern condenser discharge port. A feasibility study has begun to assess the effect of temporarily denying the eastern discharge port to fish during the late autumn - early winter period. If this study determines it is feasible to prevent fish from remaining in the discharge canal, further mitigation of cold shock fish kill losses may be possible.

7) Conclusion

Extensive monitoring of before, during and after the 1/5/80 shutdown of OCNCS has shown that approximately 7000 fish died. The mortality occurred because the ambient temperature was below the lower lethal temperatures of the seven affected species. The size of the kill is about one to two orders of magnitude lower than kills which occurred prior to 1975 when changes were made at OCNCS to mitigate cold shock fish kills but is greater than all post 1975 kills. The commercial value of the kill is about \$350.

Future work at OCNGS will be directed at further mitigation of the cold shock potential.

8) References

- 1) American Fisheries Society, 1979, Fish kill counting guidelines, Rept. by Southern Division, AFS. 25 pgs.
- 2) JCP&L, 1978, Oyster Creek Nuclear Generating Station 316 (a) & (b) Demonstration, Technical Report to USEPA and NJDEP, Five Volumes.
- 3) Woodward-Envicon, Inc. 1973, Oyster Creek Nuclear Generating Station Thermal Reconnaissance and Station Shutdown Surveys, Technical Report, 19 pgs.
- 4) Masnik, M. T., 1980, Trip Report - Oyster Creek Generating Station - Investigation of Coldshock Fishkill on January 7, 1970, Report to USNRC, 6 pgs.
- 5) Danila, D. 1980, Personal communication.
- 6) National Marine Fisheries Service, 1979, New Jersey Landings, December 1978, Technical Report #7716, NOAA, 4 pgs.
- 7) Reintjes, J. W., 1975, Compilation and correlation analysis of published and unpublished environmental data with distribution, abundance, and movements of young menhaden in mid-Atlantic estuaries, Nat. Mar. Fish Service, 40 pgs.
- 8) Ichthyological Associates, Inc. 1979, Ecological studies for the Oyster Creek Generating Station, Report of 9/77 - 8/78 to JCP&L, 391 pgs.
- 9) PSE&G, 1980, Personal communication with Mark London.
- 10) Ecological Analysts, in prep., annual report on the Oyster Creek Environmental Technical Specifications.
- 11) Hildebrand, S. F. and W. C. Schroeder 1928, Fishes of Chesapeake Bay, Fish & Wildlife Serv., Fishery Bull, V. 53, pt 1, 388 pgs.

Table 1

Average Water Temperature (F) at OCNGS

<u>Date</u>	<u>Intake</u>	<u>Discharge</u>
December 26, 1979	43.2	62.4
27	40.6	60.0
28	38.7	58.3
29	39.1	58.0
30	38.9	58.1
31	38.5	57.7
January 1, 1980	38.0	57.0
2	38.6	57.5
3	37.7	56.6
4	36.4	55.1
Shutdown		
5	33.9	36.9
6	32.8	34.5
7	33.2	34.6
8	33.7	35.5
9	33.8	35.4
10	33.1	34.4

OCNGS Shutdown Sequence

<u>Date</u>	<u>Time</u>	<u>Action</u>
1/4/80	2200	Controlled shutdown started
1/4/80	2300	Shutdown of 2 dilution pumps at 70% power
1/4/80	2342	Shutdown of one circulating wat pump
1/5/80	0225	OCNGS Shutdown

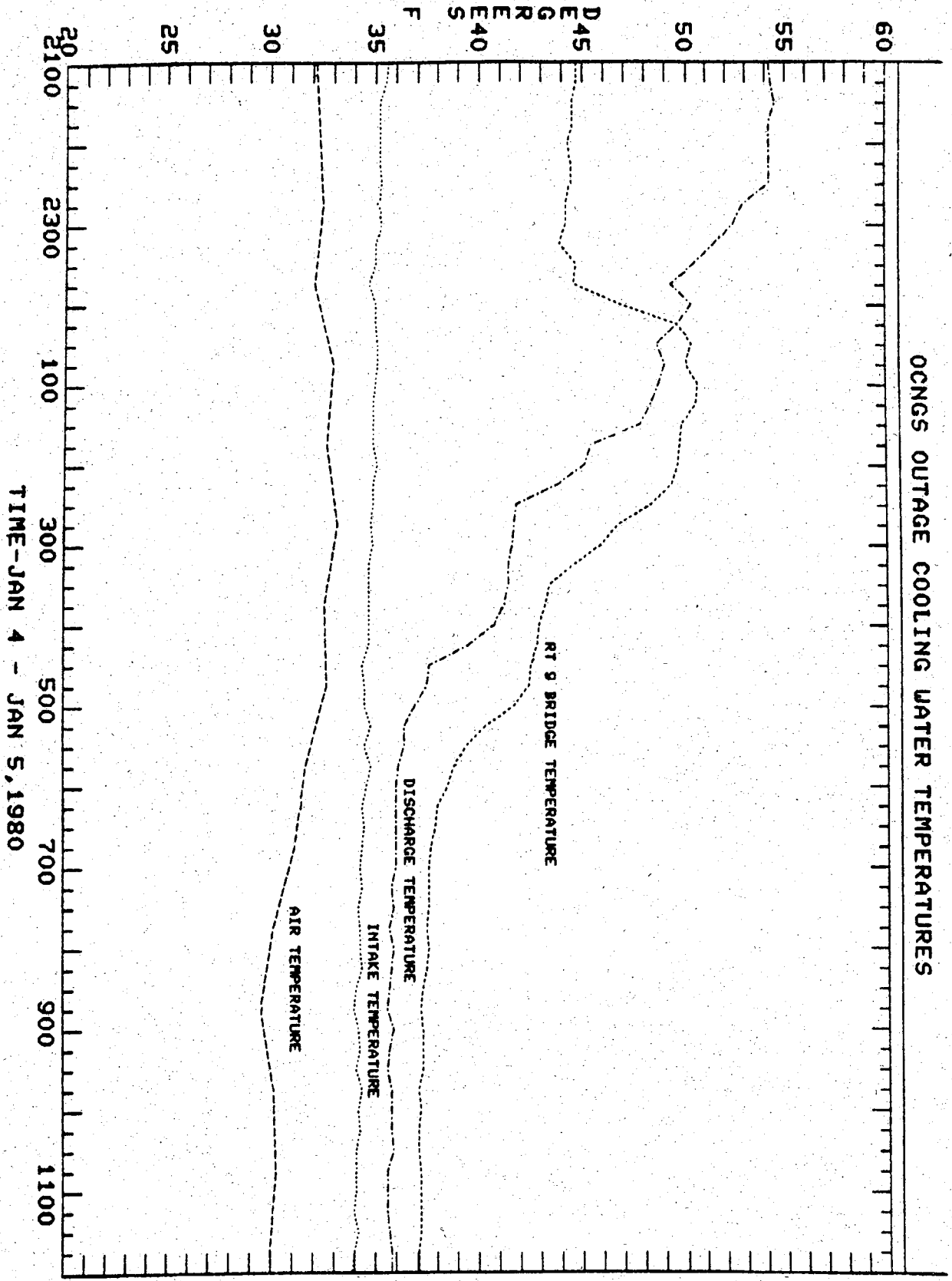
Table 3 Cold Shock Information on Selected Fish Species

<u>Species</u>	Field Observed Mortality	Lab Derived Mortality	
	<u>Lethal Temperature</u>	<u>Lethal Temperature</u>	<u>Acclimation Temperature</u>
Atlantic menhaden	3.0°C (Reintjes, 1975)	5° to 7°C	15°C (Reintjes, 1975)
	4.4° to 5.6°C (JCP&L, 1978)	7.5°C	14°C (JCP&L, 1978)
Bluefish	Between 8.5° and 3.3°C (JCP&L, 1978)	8.3°C	15°C (IA, 1979)
Weakfish	-	Below 10°C	(IA, 1979)
Jacks	8.9°C (JCP&L, 1978)	-	-
	9.8°C (Hoff, 1971)		
Spot	-	3°C	10°C (PSE&G, 1980)

Table 4: Known fish mortality at the OCNGS since the initiation of plant operation until present (Roche, 1976 - Revised 1977 and 1979).

	NUMBER	SPECIES	SIZE RANGE	PROBABLE CAUSE	INTAKE TEMPERATURE °C(°F)
1/29/72	100,000-1,000,000	Atlantic menhaden	76-127 mm	Thermal Shock	1.7 (35) (1230 pm)
1/5-1/8/73	18,000-1,200,000	Atlantic menhaden	102-356 mm	"	5.6 (42) (1800 pm, 1/5)
20		Bay anchovy	--	"	
2/16-2/21/73	Several Thousand	Atlantic menhaden	--	"	4.4 (40) (1230 am)
8/9/73	2,000-4,000	Atlantic menhaden	127-356 mm	"	28.9 (84) (830 pm)
1/7/74	500	Atlantic menhaden	203-280 mm	Chlorine	3.3 (38) (430 pm)
1/11-1/15/74	9,900-180,000	Atlantic menhaden	102-356 mm	Thermal Shock	1.7 (35) (830 pm)
	100-3,600	Bluefish	228-356 mm	"	
10/9/74	200	Cravelle jack	--	"	13.9 (57)
2/4/75	100	Atlantic menhaden	--	"	3.3 (38) (0030 am)
	50-100	Bluefish	--	"	
11/24/75	7-100	Cravelle jack	--	"	8.9 (48) (0300 am)
12/29/75	15-100	Atlantic menhaden	100-250 mm	"	2.8 (37) (740 am)
	3-200	Bluefish	90-170 mm	"	
12/27/75	350	Atlantic menhaden	120-150 mm	PH	2.2 (36) (1000 pm)
10/21/77	120-200	Blue runner Cravelle jack		Thermal Shock	12.2 (54) (1 am)
1/15/79	682	Atlantic menh	165-225 mm	"	0 (32) (630 pm)

Figure 1



ATTACHMENT I

ATTACHMENT 1

OYSTER CREEK 1980 OUTAGE FISH SURVEY REPORT

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January 1980

In response to regulatory agency requests, samples of the fish fauna of Oyster Creek were collected just prior to (Jan. 2 and Jan. 3) and following (Jan. 7) the shutdown of the Oyster Creek Station on January 5, 1980.

Samples were collected at the four locations indicated on Figure 1, using a 4.8 meter semiballoon trawl and a 60 m x 2.4 m monofilament gill net. The trawl consisted of a 3.9 cm stretch mesh body and a 3.2 cm stretch mesh cod end with a 1.3 cm stretch mesh liner. The gill net consisted of two 30 meter panels, one of 3.9 cm stretch mesh and the other of 8.5 cm stretch mesh.

On January 2, two consecutive 5-minute hauls of the trawl were made at stations 1 and 3; a single haul, the length of the lagoon (approx. 6 min) was made at station 2. This trawling sequence was repeated on January 7. At station 1, two half-hour gill net sets were made on January 3. Ice sheets prevented the use of the gill net at station 1 on January 7. The gill net was fished for approximately 10 minutes at station 4 on January 3 and 7. Strong currents in the condenser discharge area caused the net to tangle and prevented sets of longer duration.

All fish captured with the nets were identified to the lowest possible taxon and enumerated (in some cases, estimated). Lengths were measured for key species.

RESULTS

The raw data are presented in Attachment I. Table 1 summarizes the results of the trawl survey. The most common species captured with the trawl were Menidia menidia (Atlantic Silverside), a bay resident and Alosa aestivalis (Blue-back herring), a cool water migrant. Three other resident species, Apeltes quadracus (Fourspine stickleback), Syngnathus fuscus (Northern pipefish) and Pseudopleuronectes americanus (Winter flounder) were also taken in the trawl. All of the above mentioned species would be expected to occur in the bay during the winter and with the exception of P. americanus were taken both prior to and following the shutdown.

Five additional species were taken in the trawl survey conducted following the station shutdown. Leiostomus xanthurus (Spot) is a warm water migrant which is common in Barnegat Bay through December and migrates out of the bay to deeper warmer waters for the winter and early spring months. During this latter period only a few individuals of this species have been taken. The relative abundance of spot in the post-shutdown samples compared with their absence prior to the shutdown indicates that they were attracted to the thermal discharge and concentrated in the portion of the canal west of Route 9. Following the shutdown stressed and dead individuals were observed in Oyster Creek and 15 were taken at station 2 where some pockets of warmer water may have existed.

Peprilus triacanthus (butterfish) is common in Barnegat Bay from September through December but rare during the remainder of the year. A single individual was taken in the trawl sample at station 2 and may have been representative of a small number of butterfish attracted to the thermal discharge.

A single Etropus microstomus (Smallmouth flounder) was taken in the trawl at station 3. This species is generally abundant in Barnegat Bay from October through December but scarce in other months. This species may be attracted to the thermal discharge but the presence of a few individuals in the bay at the time of sampling is not unusual.

One Pomatomus saltatrix (Bluefish), apparently dead for some time, was taken in the post-shutdown trawl at station 1. The Bluefish is a warm water migrant which is attracted to the thermal discharge during its fall migration out of the bay. Following the shutdown, water temperatures in Oyster Creek fell below its lower lethal temperature.

Eight Brevoortia tyrannus (Atlantic menhaden) were collected at stations 1 and 3 during the post shutdown trawl survey. Five menhaden were dead at the time of capture and all of those were adults (age 2-3). One adult and two juvenile menhaden were taken alive at station 2 where pockets of warm water may have existed.

Brevoortia is also a warm water migrant which is attracted to the thermal discharge during the fall movement out of the bay.

No fish were taken in the 30 minute gill net sets at station 1 on January 3, two days prior to the shutdown. A five minute gill net set at station 4 (condenser discharge) on January 3 yielded 77 Atlantic menhaden averaging 24 cm in length (age 2-3). A large school of menhaden was observed swimming into the current at the condenser discharge at that time. No fish were taken with the gill net at station 4 subsequent to the shutdown.

CONCLUSIONS

The results of the pre- and post-shutdown trawl and gill net sampling indicate that at least three species (L. xanthurus, B. tyrannus and P. saltatrix) are attracted to the thermal discharge and remained in Oyster Creek when they would normally have left the bay system. The shutdown of the Oyster Creek Station resulted in mortalities to all three species.

The pre-shutdown survey results indicated a lack of pelagic species, such as Brevoortia and Pomatomus in the area of Oyster Creek east of the Route 9 bridge. Large concentrations of Brevoortia, however, were found in the condenser discharge area. Following the shutdown, Brevoortia, Pomatomus and Cynoscion (Weakfish) were observed dead and dying both east and west of the Route 9 bridge. These results indicate that those species that are attracted to the thermal discharge tend to concentrate in the relatively small area west of the Route 9 bridge as ambient water temperatures decline.

Species	Pre-Shutdown Stations			Post-Shutdown Stations		
	1	2	3	1	2	3
<u>Menidia menidia</u>	1	90	2	1	5	74
<u>Alosa aestivalis</u>	51	14	5	1	1	2
<u>Apeltes quadracus</u>			1	48		1
<u>Pseudopleuronectes americanus</u>	1	4	2			
<u>Syngnathus fuscus</u>		1	1	1		
<u>Etropus microstomus</u>						1
<u>Leiostomus xanthurus</u>					15	1
<u>Peprilus triacanthus</u>					1	
<u>Brevoortia tyrannus</u>					5	2
<u>Pomatomus saltatrix</u>				1		
Totals	53	109	11	52	27	81

Table 1. Number of individuals per 5 minute trawl. Station 1 = Oyster Creek Mouth; Station 2 = Eastern Lagoon; Station 3 = Oyster Creek Route 9 bridge area.

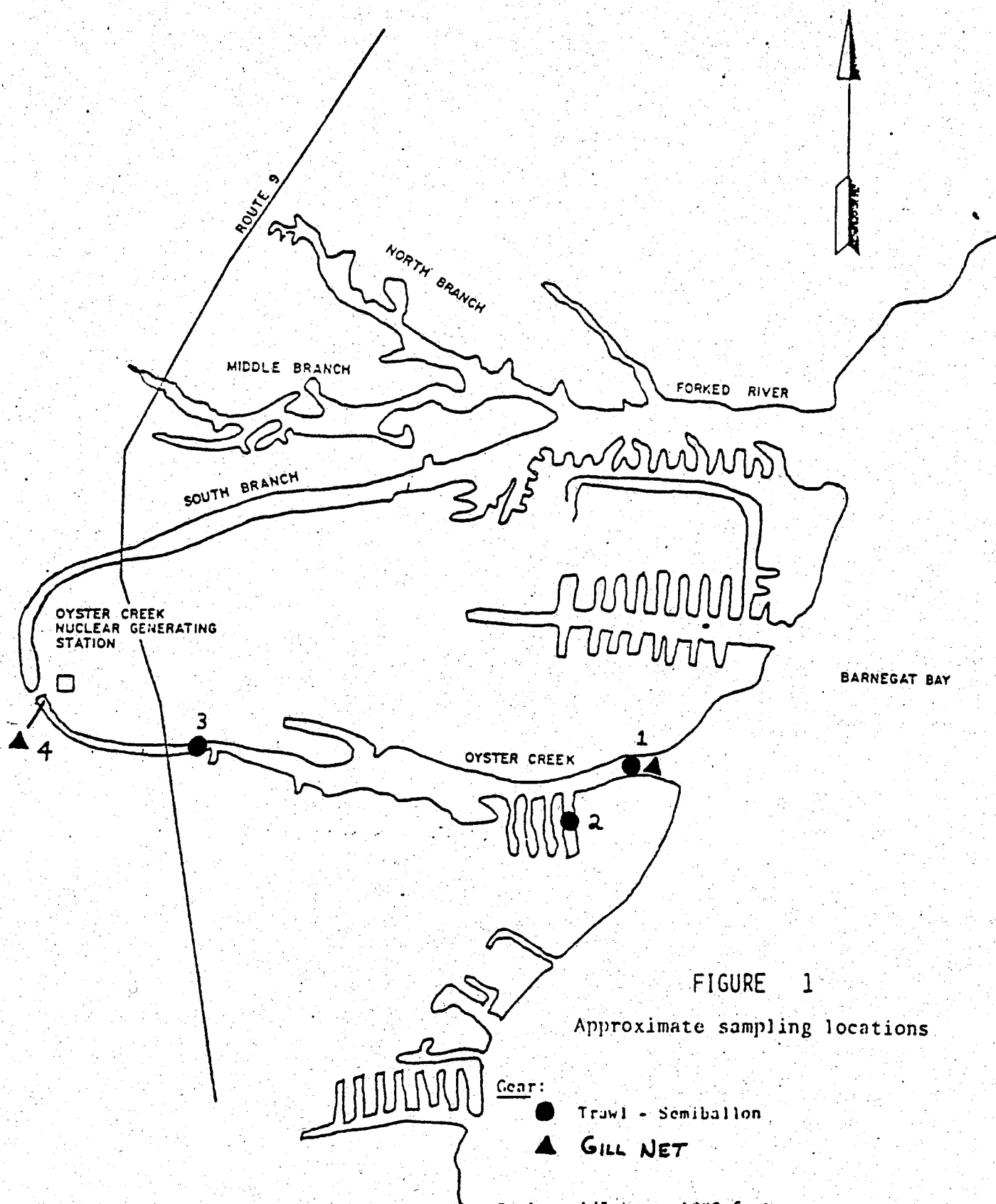


FIGURE 1

Approximate sampling locations



STATION OYSTER CREEK MOUTH

(1)

DATE 1/2/80
TIME 1630

GEAR TRAWL

REPLICATE 1 of 2

TEMP - SURFACE-
BOTTOM-

SALINITY-SURFACE-
BOTTOM-

TAXA

NO.

LENGTHS (cm)

ALOSA AESTIVALIS

102

5-8

MENIDIA MENIDIA

2

7-10



STATION OYSTER CREEK MOUTH

①

DATE 1/2/80
TIME 1630

GEAR TRAWL

REPLICATE 2 OF 2

TEMP - SURFACE-
BOTTOM-

SALINITY-SURFACE-
BOTTOM-

TAXA

NO.

LENGTHS (cm)

PSEUDOPLEURONECTES AMERICANUS

2

11.5, 30.5



STATION EASTERN LAGOON (2)

DATE 1/2/80
TIME 1700

GEAR TRAWL ~400 meters covered by trawl

REPLICATE 1 of 1

TEMP - SURFACE- 8.0°C
BOTTOM- 8.0

SALINITY-SURFACE- 18 ppt
BOTTOM- 20

TAXA	NO.	LENGTHS (cm)
<u>ALOSA RESTIVALIS</u>	14	1-10
<u>MENIDIA MENIDIA</u>	90	7-13
<u>PSEUDOPLEURONECTES AMERICANUS</u>	4	9.5, 12.5, 22.5, 27.0
<u>LYNGNATHUS FUSCUS</u>	1	15.0



STATION RT 9 BRIDGE AREA OF O.C. (3)

DATE 1/2/80
TIME 1730

GEAR TRAWL

REPLICATE 1 OF 2

TEMP - SURFACE - 8.0°C
BOTTOM - 8.0

SALINITY - SURFACE - 20.5 ppt
BOTTOM - 20.5

TAXA

NO.

LENGTHS (cm)

MENIDIA MENIDIA

3

7-12

PSEUDOPLEURONECTES AMERICANUS

1

35.0



STATION RT 9 BRIDGE AREA OF O.C. (3)

DATE 1/2/80
TIME 1750

GEAR TRAWL

REPLICATE 2 OF 2

TEMP - SURFACE- 8.5 °C
BOTTOM- 8.5

SALINITY-SURFACE- 20.5 ppt
BOTTOM- 20.5

TAXA	NO.	LENGTHS (cm)
<u>ALOSA AESTIVALIS</u>	10	1-10
<u>PSEUDOPLEURONCTES AMERICANUS</u>	2	12.5, 13.5
<u>S. FUSCUS</u>	2	14.0, 20.0
<u>APOLTES QUADRACUS</u>	1	4.0



STATION OYSTER CREEK - JUST WEST OF MOUTH

①

DATE 1/3/80
TIME 0745

GEAR GILL NET

REPLICATE 1 & 2

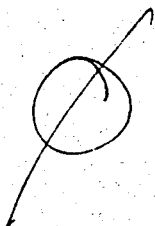
TEMP - SURFACE - 7.9°C
BOTTOM - 7.9

SALINITY - SURFACE - 16 PPT
BOTTOM - 16

TAXA

NO.

LENGTHS (cm)





STATION O.C. CONDENSER DISCHARGE

(4)

DATE 1/3/80
TIME 1000

GEAR Gill NET

REPLICATE 1 of 1

TEMP - SURFACE-
BOTTOM-SALINITY-SURFACE-
BOTTOM-

TAXA

NO.

LENGTHS (cm)

BREVOORTIA TYRANNUS

77

27.0	23.0
24.5	23.7
24.4	25.5
24.0	25.0
22.0	26.8
23.2	25.0
23.5	23.0
23.0	23.5
26.5	21.9
24.0	24.6
24.0	24.0
28.5	22.8
25.0	22.3
21.8	26.7
24.8	22.5
26.0	22.0
23.5	25.5
23.0	23.6
25.5	23.0
24.0	23.1
25.5	22.3
22.5	25.2
23.2	23.7
22.7	23.5
21.8	25.0
27.5	24.7
22.5	23.0
23.5	23.0
23.0	24.4
23.5	24.6
23.0	24.0
23.5	26.2
24.5	23.0
23.3	22.2
23.0	21.4
28.5	22.5
26.0	23.0
25.5	26.1
	22.5
	26.5
	22.6

X=24.0



STATION OYSTER CREEK MOUTH (1)

DATE 1/7/80
TIME 1015

GEAR TRAWL

REPLICATE 1 OF 2

ICE SHEETS JUST INSIDE OF MOUTH OF O.C.

TEMP - SURFACE - 2.0°C
BOTTOM - 2.0

SALINITY - SURFACE - 17.5 ppt
BOTTOM - 17.5

TAXA

NO.

LENGTHS (cm)

APELTES QUADRATUS

65

2-5

MENIDIA MENIDIA

1

ALOSA AESTIVALS

1

POMATOMUS SALATRIX (DEAD)

1

STATION OYSTER CREEK MOUTH (1)

DATE 1/7/80
TIME 1045

GEAR TRAWL

REPLICATE 2 OF 2

TEMP - SURFACE-
BOTTOM-

ICE SHEETS JUST INSIDE MOUTH OF O.C.

SALINITY-SURFACE-
BOTTOM-

TAXA

NO.

LENGTHS (cm)

APELTES QUADRATUS

20-30

SYNGNATHUS FUSCUS

1



STATION EASTERN LAGOON (2)

DATE 1/7/80
TIME 1115

GEAR TRAWL

N 400 meters covered by trawl

REPLICATE 1 of 1

TEMP - SURFACE-
BOTTOM-

ENTIRE LAGOON SURFACE COVERED WITH ICE

SALINITY-SURFACE-
BOTTOM-

TAXA

NO.

LENGTHS (cm)

LEGIOSOMUS XANTHURUS

15

10-15

MENIDIA MENIDIA

5

BREVORTIA TYRANNUS

5

3 LING 2 DEAD

4 ~ 25cm

1 ~ 8cm

ALOSA RESTUOLIS

1

PEPRILUS TRIACANTHUS

1

12.0



STATION Rt 9 Bridge Region - O. C. (3)

DATE 1/7/80
TIME 1145

GEAR Trawl

REPLICATE 1 of 2

TEMP - SURFACE - 2.0°C
BOTTOM - 2.0

SALINITY - SURFACE - 18 ppt
BOTTOM - 18

TAXA

NO.

LENGTHS (cm)

MENIDIA MENIDIA

97

ALOSA AESTIVALS

3

BREVDORTIA TYRANNUS (OEOO)

1

L. STOMUS XANTHURUS

1



STATION Rt 9 BRIDGE REGION OF O.C. (3)

DATE 1/7/80
TIME 12/5

GEAR TRAWL

REPLICATE 2 OF 2

TEMP - SURFACE-
BOTTOM-

SALINITY-SURFACE-
BOTTOM-

TAXA

NO.

LENGTHS (cm)

MENIDIA MENIDIA

51

BREVOORTIA TYRANNUS (DEAD)

2

ETRUPUS MICROSTOMUS

1

APELTES QUADORACUS

1

PLOSA ABSTIVALIS

1



STATION Oyster Creek Condenser Discharge (4)

DATE 1/2/80
TIME 1300

GEAR Gill Net

REPLICATE 1 of 1

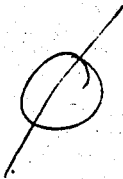
TEMP - SURFACE-
BOTTOM-

SALINITY-SURFACE-
BOTTOM-

TAXA

NO.

LENGTHS (cm)



Attachment II

Calculations of Number of Fish Killed

1) OC Shoreline

1.1) Actual = # of fish counted along shore

1.2) Estimate = Actual/75%

2) OC Bottom

2.1) Actual = # of fish collected in 4 trawls in O.C.

2.2) Specimen per area = Actual/(trawl width x total trawl length)

Specimen per area = Actual/ (.0048km x 2.6943 km)

2.3) Bottom estimate = Specimen per area x area of bottom in O.C.

Bottom estimate = Specimen per area x .305 sq. km.

2.4) Bottom and shore estimate = Bottom estimate/25%

3) OC Lagoons

3.1) Actual = # of fish collected in trawl in eastern lagoon

3.2) Specimen per area = Actual/(trawl width x trawl length)

Specimen per area = Actual/ (.0048 km x .333 km)

3.3) Lagoon estimate = Specimen per area x area of bottom in 4 lagoons

Lagoon estimate = Specimen per area x .04 sq. km.